

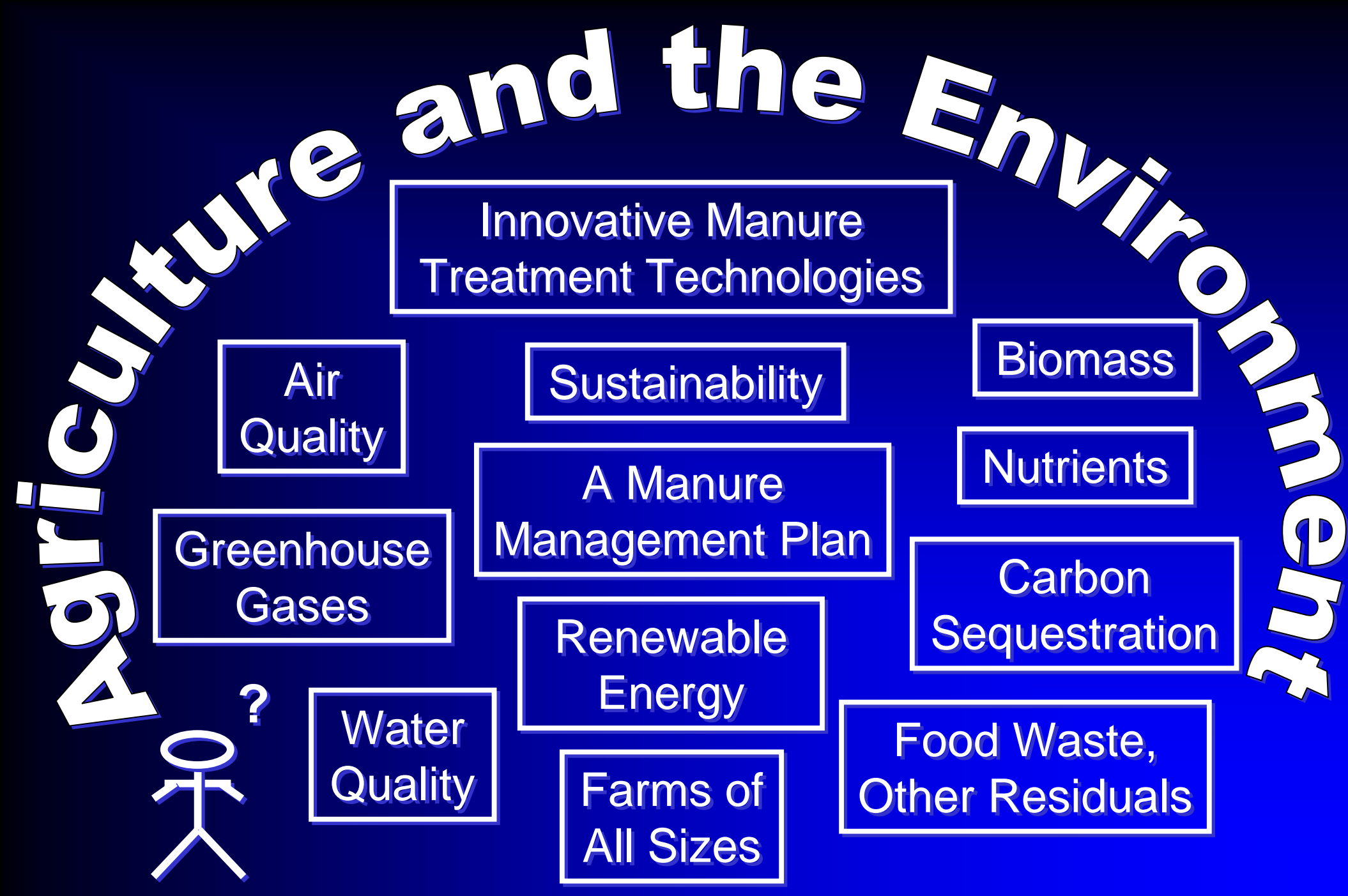
Key Factors to Consider When Choosing Anaerobic Digestion as a Component in a Sustainable Manure Management Plan

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Biosystems and Agricultural Engineering

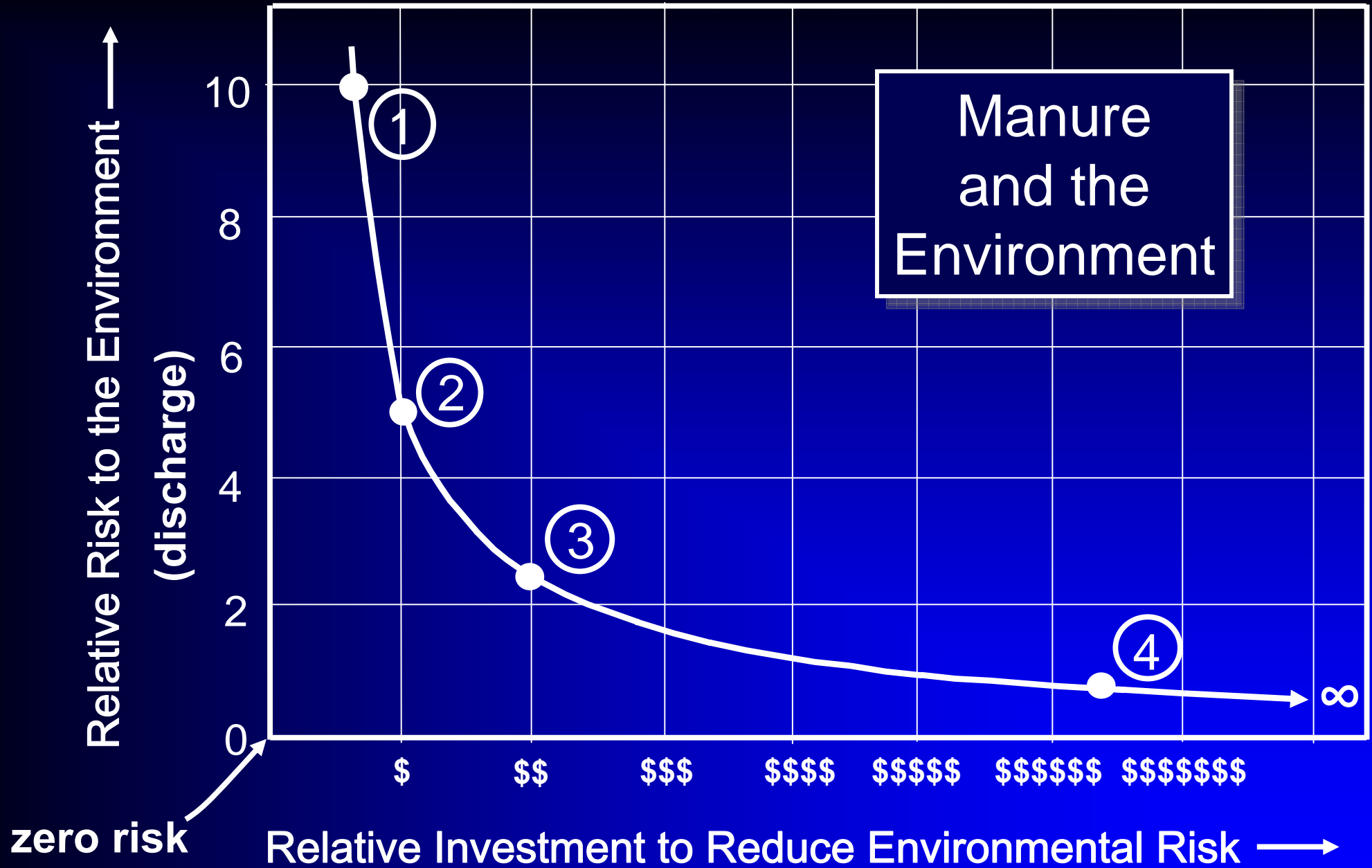
Michigan State University

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Q: How did manure handling
get to be so complicated—
and so expensive?

A: Manure management is more
than pushing the manure out the
barn door—or, OHOS
(over the hill and out of sight)!



Important issues in animal agriculture

- Manure management
- Animal welfare
- Food safety

Perception of
manure has
changed over
the years...

Resource



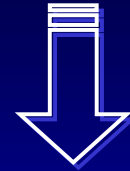
Waste



Environmental
Contaminant

Perception of
manure has
changed over
the years...

Resource



1940's

Waste



1970's

Environmental
Contaminant



We must develop manure management systems that are:

- Affordable to the farmer
- Friendly to the environment
- Acceptable to society

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At one time, an important
question was...

Will the manure be handled as
a solid (\$) or a liquid (\$\$)?

Manure system developments, relative complexity and cost:

- Daily haul, land apply—\$
- Store >6 mo, land apply—\$\$, \$\$\$
- Treat, store >6mo, land apply—\$\$\$\$\$?

An investment in manure
management **reduces**
net farm income!

Farmers invested in long term storage, etc...

- For convenience
- To better utilize nutrients
- To reduce pollution

Viewing Manure as a Resource (\$\$\$)

- As a nutrient in the cropping program
- Sell as is or nutrient enhanced
- Compost, a soil amendment
- Separate components w/ value; e.g., P
- Energy source (pyrolysis, ***digester***, ...)

Anaerobic digester → biogas → electricity

Biogas yield: $50-80 \text{ ft}^3/\text{day}$ from the manure
from one dairy cow.

Biogas contains about $600 \text{ Btu}/\text{ft}^3$...
results in $30,000-48,000 \text{ Btu}/\text{day}$.

At $3,415 \text{ Btu}/\text{KWH}$ & 20% efficiency... One
dairy cow yields $1.7-2.8 \text{ Kwh}/\text{cow}/\text{day}$

One dairy cow \rightarrow 1.7-2.8 KWH/cow/day ,
and electricity is worth \$0.07/KWH,

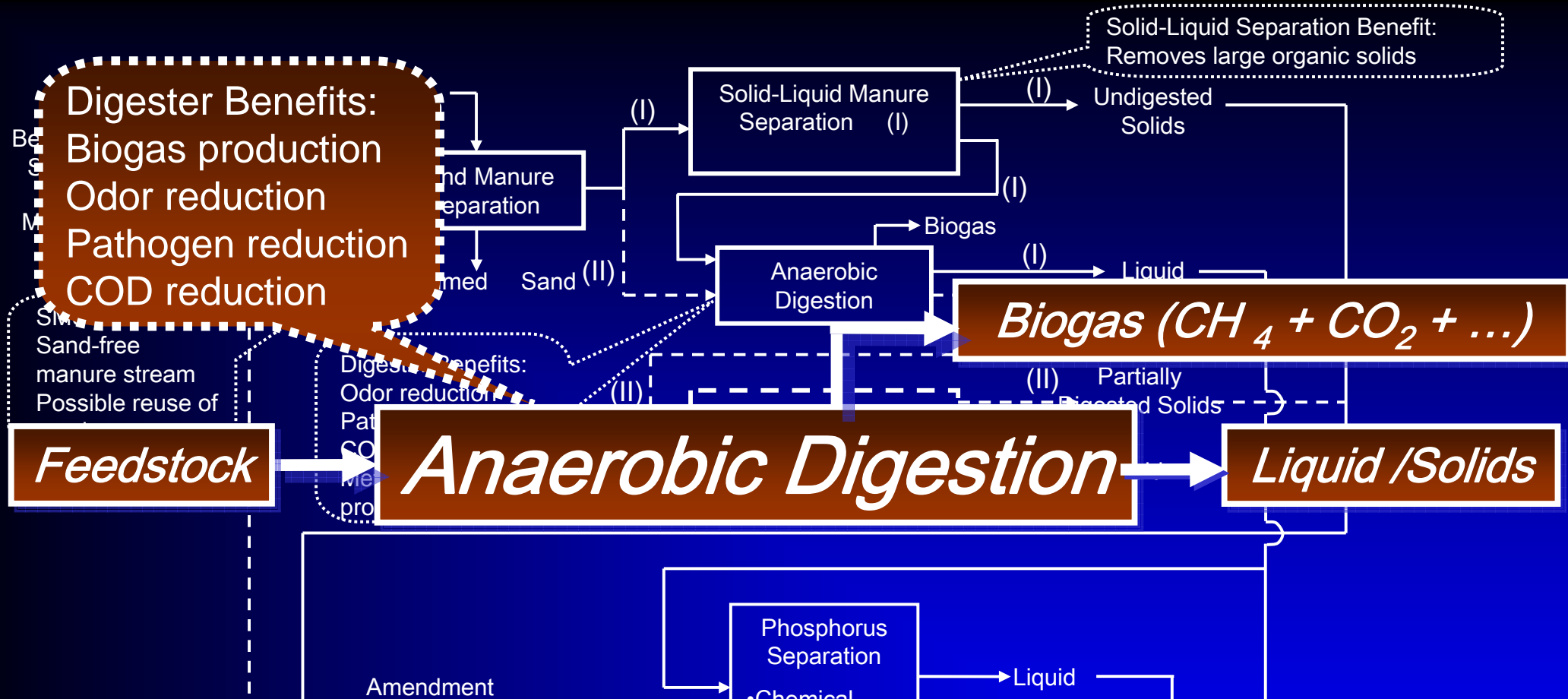
The manure from one cow produces
\$0.12-0.20 of electricity each day.

“Making a manure digester pay”

by Stowell & Henry, Hoards Dairyman, August 25, 2004

	Number of milking cows		
	100	500	1,000
Capital cost, digester & generator, bare-bones	\$98,000	\$190,000	\$296,000
Maximum digester electric output	102,000 kwh	460,000 kwh	921,000 kwh
Excess electricity sold @ 2¢/kwh	0 kwh	69,000 kwh	102,000 kwh
Break-even electrical cost from utility	18¢/kwh	9¢/kwh	8¢/kwh

For example, for operations with 1,000 cows, a break-even price of at least 8¢/kwh is required if other incentives are not available.



An Integrated Manure Management System

Integrated Manure Management System

A system for treating manure, based on synergistic components, designed to produce the desired output streams.

For example...

A phosphorus removal system uses less chemicals if the input manure stream is in an *anaerobic* state—a savings in \$\$.



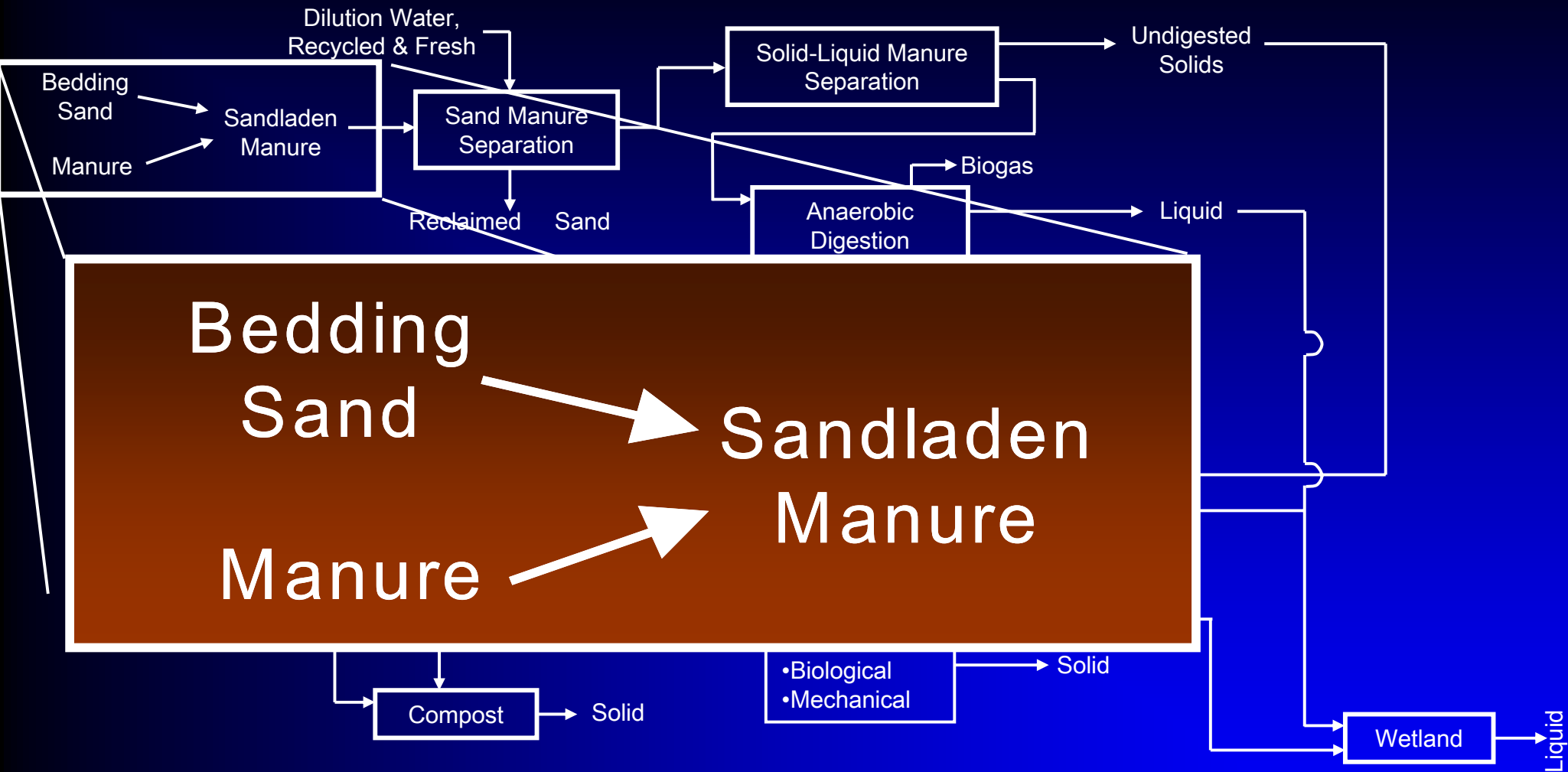
Sand is the gold standard
for freestall bedding!



**Cow comfort
and
cleanliness**

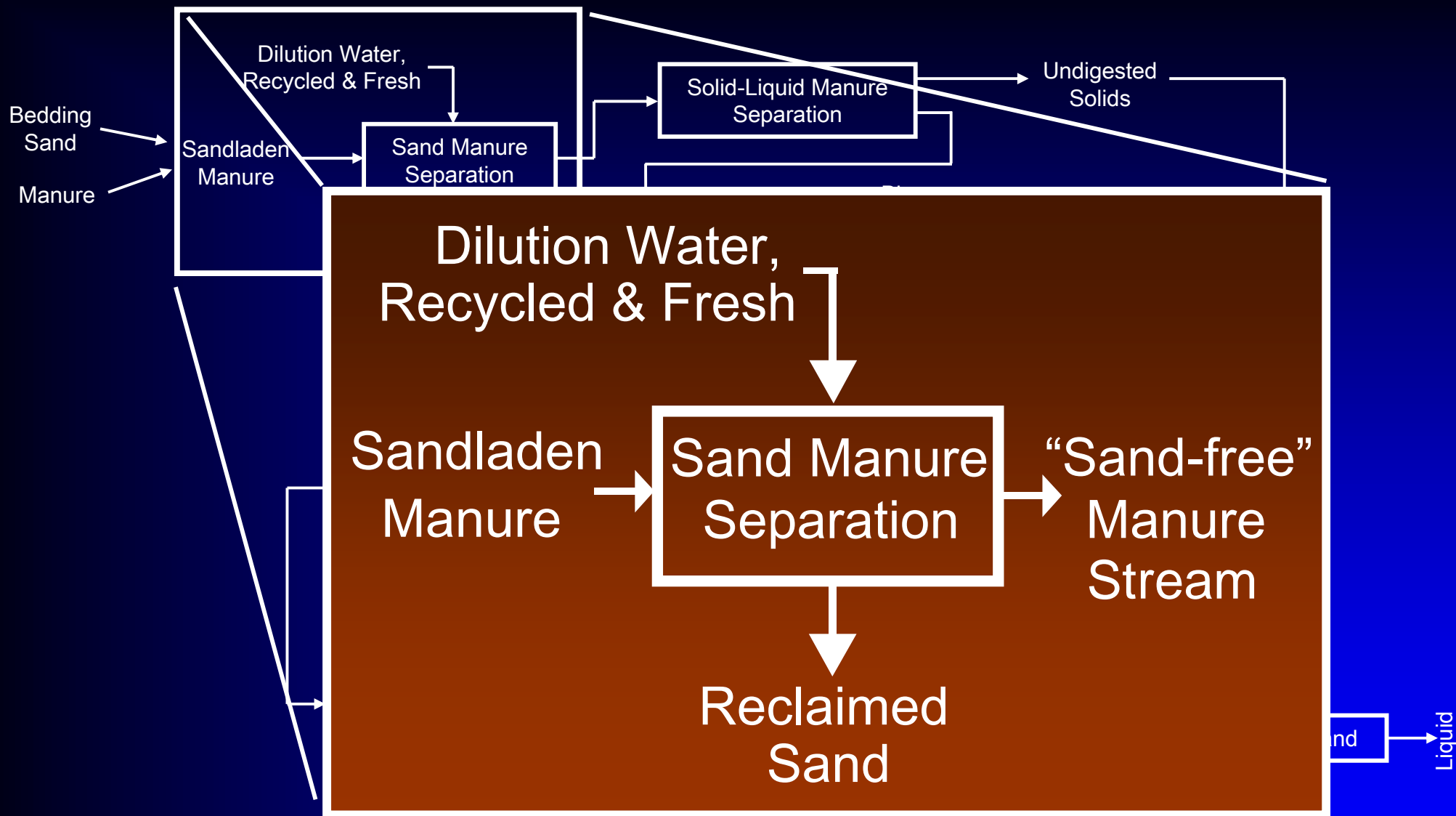
**Ease of
handling
manure**

**The only reason not to
use sand for freestalls!**



Rule #1 in handling sandladen manure:

Do not put a manure stream containing
sand in a place where the settled sand
cannot be easily removed!
(Including an anaerobic digester)



Biomass or animal
waste feedstock



*Fermenting
microbes*

Conversion
of biomass
to sugars &
fermentation

**Sugars
+
Alcohol**

*Hydrogen
producing
microbes*

Alcohols and
Fatty acids
→ Organic
acids and
hydrogen

**H₂
+
COOH
+
CO₂**

Anaerobic Digestion:

Three stages of
interacting microbial
digestion

Biogas

CH₄

+

CO₂

+

H₂O

*Methane
producing
microbes*

Conversion of
acetate and hydrogen
→ methane (CH₄)

Hierarchy of (bio)methane (CH₄)...

Renewable energy →

Biomass →

Organic matter (cellulose/carbon) →

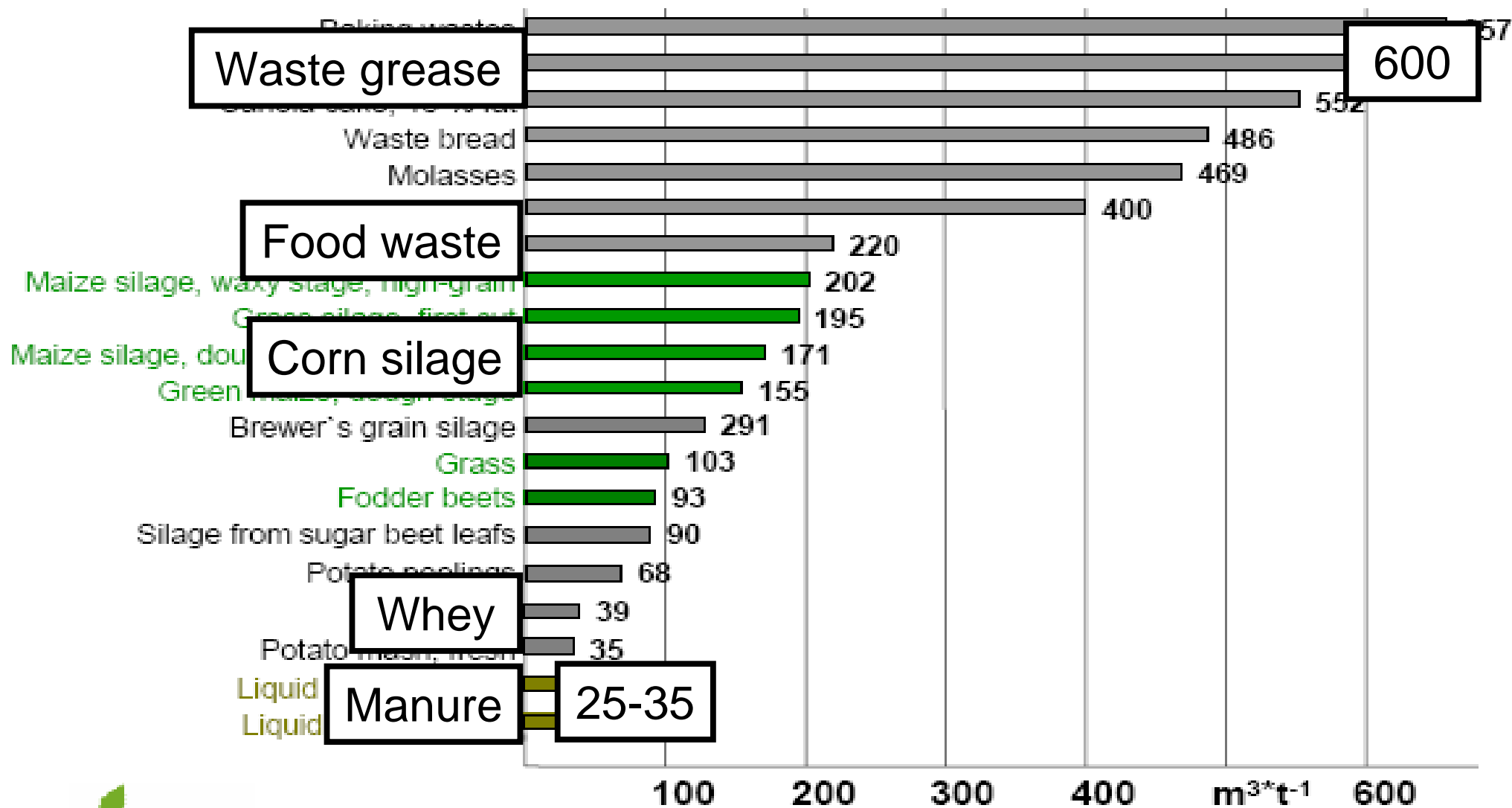
Anaerobic digestion (fermentation) →

Biogas (a biofuel) →

Methane

Biomass is
organic matter—
cellulose, hemicellulose or lignin
—which is available on a renewable
or recurring basis

Potential Biogas Yields







We must develop manure management systems that are:

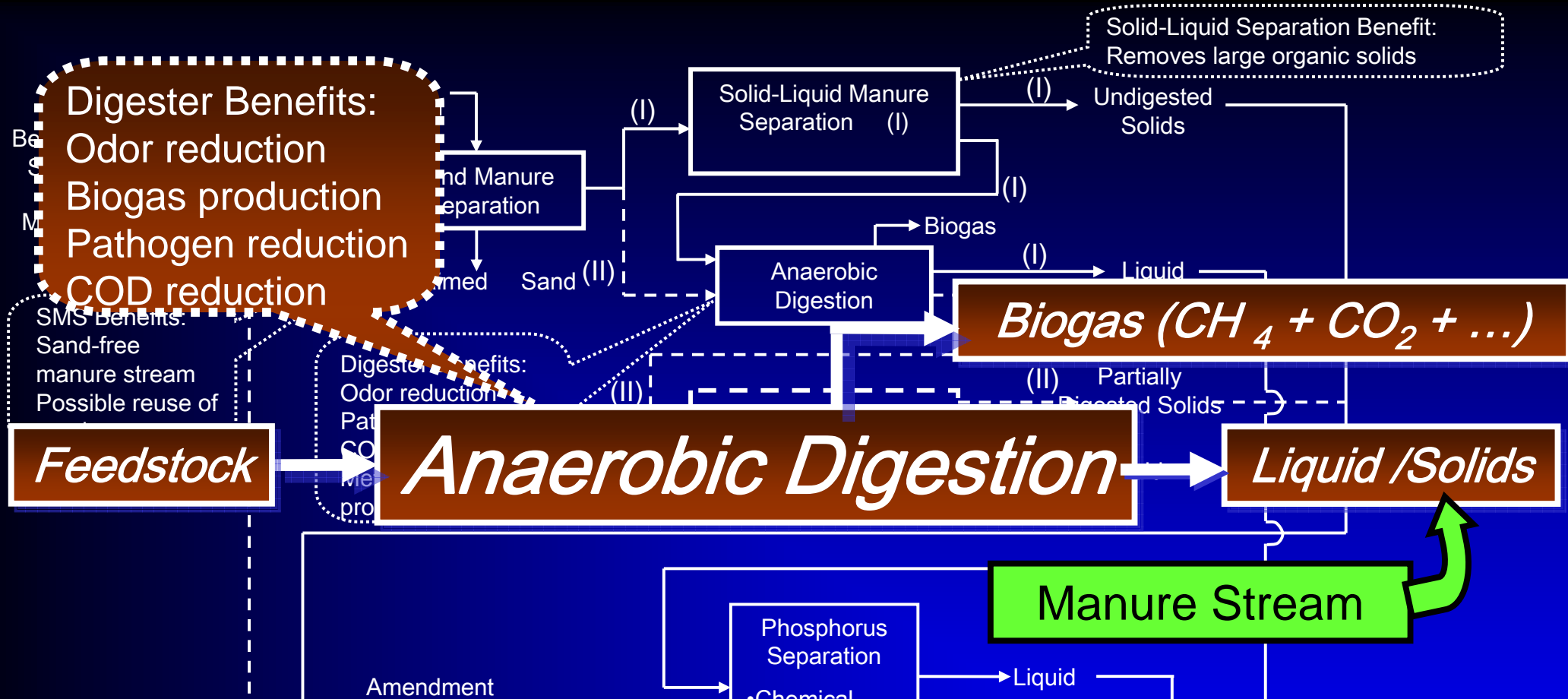
- Affordable to the farmer
- Friendly to the environment
- Acceptable to society

Potential Environmental Contaminants

- Odors
- Nutrients
- Pathogens
- And more







An Integrated Manure Management System

Compost Benefits:
Odor reduction
Volume reduction
Value-added product

P Removal Benefits: More spreading options
Distance hauling
Value-added product?

Wetland Benefits: Pathogen reduction
Carbon reduction
Nitrogen reduction
Improved water quality

An Integrated Manure Management System

The manure stream from an anaerobic digester contains...

- Pathogens
- Nutrients

and, therefore, can be a significant source of pollution!

“Keep Land-Applied Manure in the Root Zone”

- First, reduce surface runoff of contaminated water.
- Then, keep it in the root zone where crops can utilize nutrients and treatment may occur.

We must develop manure management systems that are:

- Affordable to the farmer
- Friendly to the environment
- Acceptable to society

Who is Society?

- Those involved in animal agriculture?
- Others in agriculture (crop farmers)?
- Those interested in agriculture?
- Everyone else?

Some people object to animal farms!



“Keep Our Air and Water Clean”

“NO MEGA FARMS”

“KEEP OUR AIR & WATER CLEAN”



“NO MORE MEGA FARMS”

Potential Environmental Contaminants

- Odors
- Nutrients
- Pathogens
- And more

Digester Benefits:
 Odor reduction
 Pathogen reduction
 Biogas production
 COD reduction

manure stream
 Possible reuse of

Feedstock

Benefits
 Odor reduction
 Pat
 CO
 me
 pro

Anaerobic Digestion

Liquid /Solids

Solid-Liquid Manure Separation (I)

Solid-Liquid Separation Benefit:
 Removes large organic solids

Undigested Solids

Anaerobic Digestion

Biogas

Biogas ($CH_4 + CO_2 + \dots$)

Partially Digested Solids

Phosphorus Separation

Liquid

Amendment

An Integrated Manure Management System

Compost Benefits:
 Odor reduction Volume reduction Value-added product

P Removal Benefits: More spreading options Distance hauling Value-added product?

Wetland Benefits: Pathogen reduction Carbon reduction Nitrogen reduction Improved water quality

An Integrated Manure Management System

WGB/AE/MSU
 21 JAN 03

Key Factors to Consider When Choosing Anaerobic Digestion as a Component in a Sustainable Manure Management Plan

An anaerobic digester, by itself, is not a complete manure treatment system.

But a digester is a cornerstone of an integrated manure management system...and sets the stage for other treatment components.

In addition...

Renewable energy →

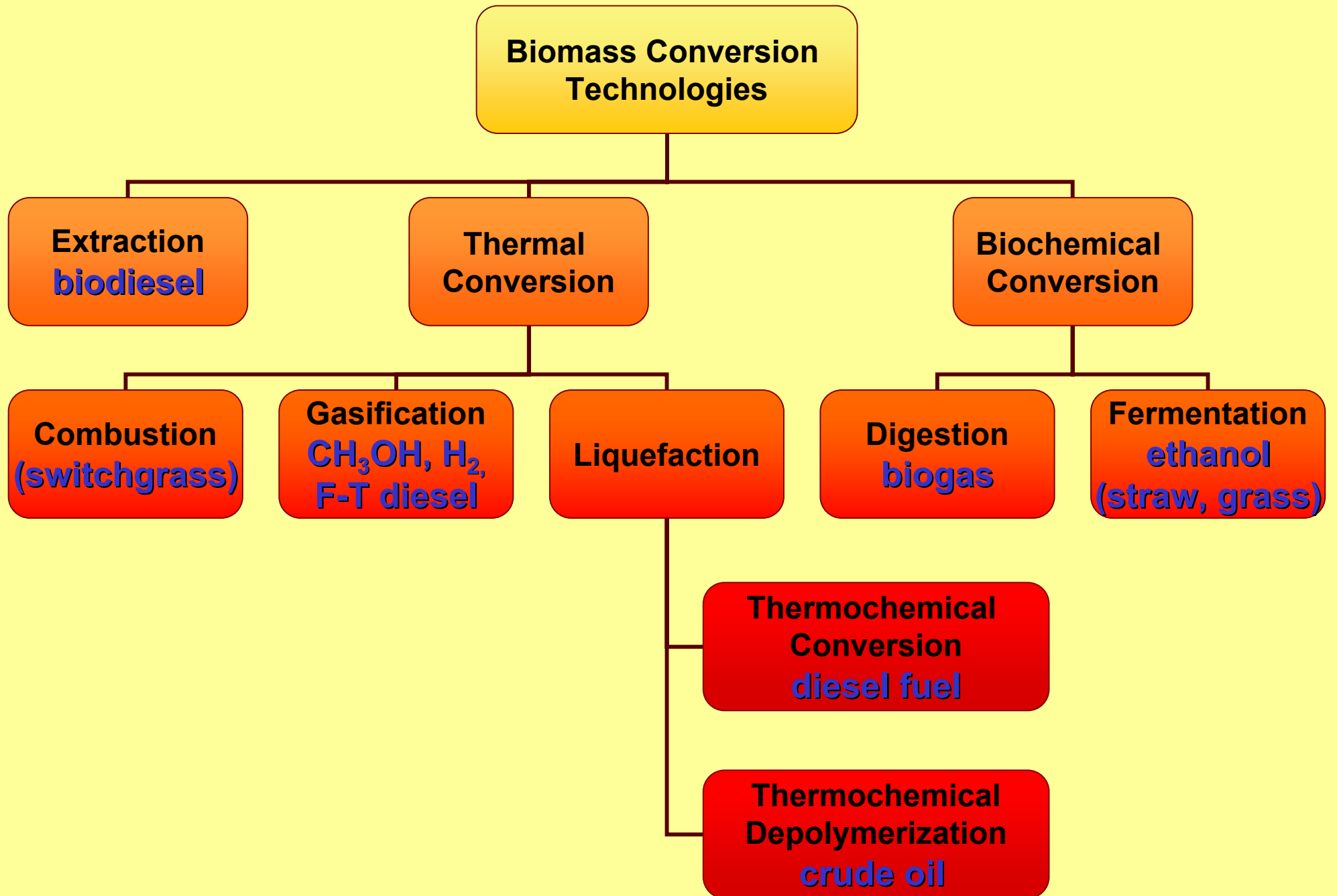
Biomass →

Organic matter (cellulose/carbon) →

Anaerobic digestion (fermentation) →

Biogas (a biofuel) →

Methane



A successful Michigan agriculture depends upon close linkages between cropping systems and animal agriculture.

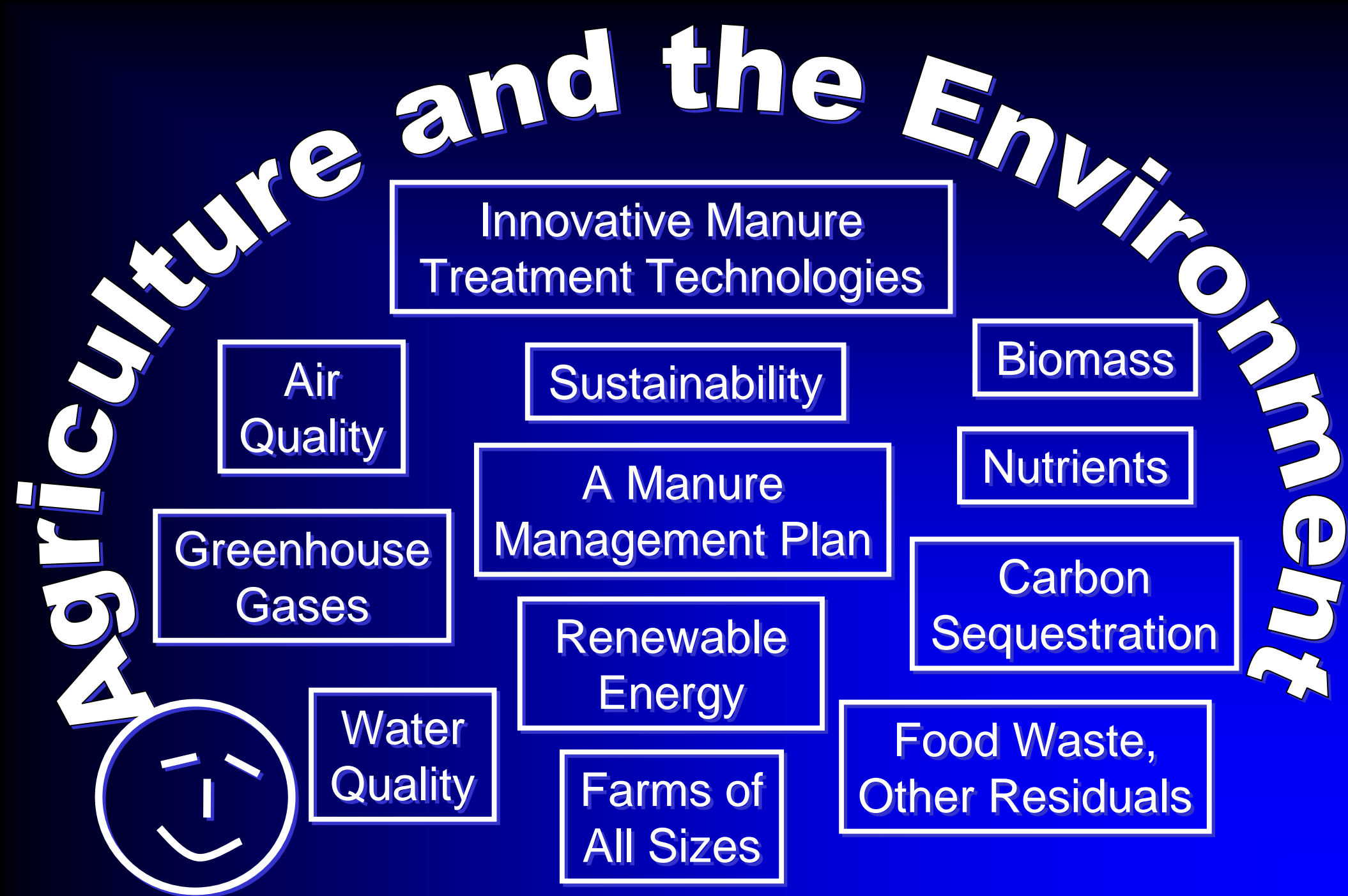
For example...

A co-product of ethanol production is *animal feed*!

Which requires a balance between crops and livestock!

Success then depends upon our ability to manage manure!

If, in the future, we are to have a thriving animal agriculture, we will have massive amounts of manure.



Challenge

To think outside the box.

To think beyond the barn door!

Even beyond the boundaries of the farm!

**We must change the way
we do things in agriculture!**